

# Nuclear Power in Germany

(June 2008)

- **Germany obtains one quarter of its electricity from nuclear energy, using 17 reactors.**
- **A coalition government formed after the 1998 federal elections has the phasing out of nuclear energy as a feature of its policy.**
- **A compromise agreement was worked out in mid 2000 and signed into effect in 2001 to limit the operational lives of nuclear power plants to an average of 32 years, deferring any immediate closures.**

Germany's electricity production in 2006 was 633 billion kWh gross, about 6300 kWh per capita. Coal provides about half of the country's electricity. The country's 17 operating nuclear power reactors, comprising 20.6% of installed capacity, supply about one quarter of the electricity (133 billion kWh net in 2007). Many of the units are large (they total 20,339 MWe), and the last came into commercial operation in 1989. Six units are boiling water reactors (BWR), 11 are pressurised water reactors (PWR). All were built by Siemens-KWU. A further PWR has not operated since 1988 because of a licensing dispute.

Responsibility for licensing the construction and operation of all nuclear facilities is shared between the federal and Länder governments, which confers something close to a power of veto to both.

When Germany was reunited in 1990, all the Soviet-designed reactors in the east were shut down for safety reasons and are being decommissioned. These comprised four operating VVER-440s, a fifth one under construction and a small older VVER reactor.

In 2000 the European Commission approved the merger of two of Germany's biggest utilities, Veba and Viag, to form E.ON, which owned or had a stake in 12 of the country's 19 nuclear reactors then.

Germany has about half of Europe's installed wind generating capacity, amounting in 2005 to about 22% of its total capacity. This provided 4.8% of the electricity.

## German nuclear power units

Plant	Type	MWe (net)	Year start	Provisionally scheduled shut-down
Biblis-A	PWR	1167	1975	2008

<b>Neckarwestheim-1</b>	PWR	785	1976	2009
<b>Brunsbüttel</b>	BWR	771	1977	2009
<b>Biblis-B</b>	PWR	1240	1977	2009 or 2011
<b>Unterweser</b>	PWR	1345	1979	2012
<b>Isar-1</b>	BWR	878	1979	2011
<b>Phillipsburg-1</b>	BWR	890	1980	2012
<b>Grafenrheinfeld</b>	PWR	1275	1982	2014
<b>Krummel</b>	BWR	1260	1884	2016
<b>Gundremmingen-B</b>	BWR	1284	1984	2016
<b>Gundremmingen-C</b>	BWR	1288	1985	2016
<b>Gröhnde</b>	PWR	1360	1985	2017
<b>Phillipsburg-2</b>	PWR	1392	1985	2018
<b>Brokdorf</b>	PWR	1370	1986	2019
<b>Isar-2</b>	PWR	1400	1988	2020
<b>Emsland</b>	PWR	1329	1988	2021
<b>Neckarwestheim-2</b>	PWR	1305	1989	2022
total (17)		20,339 MWe		

## Nuclear power policy

German support for nuclear energy was very strong in the 1970s following the oil price shock of 1974, and there was a perception of vulnerability regarding energy supplies. However, this policy faltered after the Chernobyl accident in 1986, and the last new nuclear power plant was commissioned in 1989. Whereas the Social Democratic Party (SPD) had affirmed nuclear power in 1979, in August 1986 it passed a resolution to abandon nuclear power within ten years.

The most immediate effect of this change of policy was to terminate R&D on both the high-temperature gas-cooled reactor and the fast breeder reactors after some 30 years of promising work, since much of the work was in North Rhine-Westphalia, which was governed by the SPD. A Christian Democrat (CDU) federal government then maintained support for existing nuclear power generation nationally until defeated in 1998.

In October 1998 a coalition government was formed between the Social Democratic Party (SPD) and the Green Party, the latter having polled only 6.7% of the vote. As a result, these two parties agreed to change the law to establish the eventual phasing out of nuclear power.

Long drawn-out "consensus talks" with the electric utilities were intended to establish a timetable for phase out, with the Greens threatening unilateral curtailment of licenses without compensation if agreement was not reached. All operating nuclear plants have unlimited licences with strong legal guarantees.

In June 2000 a compromise was announced which saved face for the government and secured the uninterrupted operation of the nuclear plants for many years ahead. The agreement, while limiting plant lifetime to some degree, averted the risk of any enforced plant closures during the term of the present government.

In particular, the agreement put a cap of 2623 billion kWh on lifetime production by all 19 operating reactors, equivalent to an average lifetime of 32 years (less than the 35 years sought by industry). Two key elements were a government commitment to respect the rights of utilities to operate existing plants, and a guarantee that this operation and related waste disposal will be protected from any "politically-motivated interference".

Other elements included: a government commitment not to introduce any "one-sided" economic or taxation measures, a recognition by the government of the high safety standards of German nuclear plants and a guarantee not to erode those standards, the resumption of spent fuel transports for reprocessing in France and UK for five years or until contracts expire, and maintenance of two waste repository projects (at Konrad and Gorleben).

In June 2001 the leaders of the Red-Green coalition government and the four main energy companies signed an agreement to give effect to this 2000 compromise. The companies' undertaking to limit the operational lives of the reactors to an average of 32 years meant that two of the least economic ones - Stade and Obrigheim - were shut down in 2003 and 2005 respectively, and the one non-operational reactor (Muelheim-Kaerlich, 1219 MWe) commenced decommissioning in 2003. It also prohibited the construction of new nuclear power plants for the time being and introduced the principle of on-site storage for spent fuel.

The agreement was a pragmatic compromise which limited political interference while providing a basis and plenty of time for formulation of a national energy policy. An industry leader reminded his government that "Reliable and cost-effective energy supply must remain an important component of German economic policy". Some speculation centred on the future of the agreement and the revised Atomic Energy Act which followed it under any new government. Parliamentary opposition party leaders said that they would reverse the decision when they can.

If the present policy continues beyond the 2006 federal election, several large plants will be forced to close, creating a significant supply problem and raising concern from industrial consumers. Utilities are preparing for a change in policy after the election however, extending all 17 reactor lifetimes initially to 40 years (from average 32 years) and then individually seeking extensions to 60 years as in the USA.

Earlier, the utilities said that while they had achieved their stated goal, "to be able to carry on operating the German nuclear power plants under economically-acceptable conditions", the deal was still a second-best solution and completely failed to address the need for "comprehensive consensus" on energy policy generally. They pointed to reasons for nuclear energy needing to remain part of the German energy mix long-term, and the importance of actively maintaining the option for future generations by adequate R&D on the new European Pressurised Water Reactor (EPR) design, a Franco-German project.

Fuelling the dispute within the grand coalition government, a January 2007 report by Deutsche Bank warned that Germany will miss its carbon dioxide emission targets by a wide margin, face higher electricity prices, suffer more blackouts and dramatically increase its dependence on gas imports from Russia as a result of its nuclear phase-out policy, if it is followed through. Unless adjustments are made to the shutdown timetable which was passed into law, four large reactors (which started up 1975-77) totaling almost 4 GWe will be shut down by the end of 2009. The Economy Minister and utility owners called for urgent review of the policy. The Bank estimates that 42 GWe of new generating capacity will need to be constructed by 2022 if shutdowns proceed.

Utilities want to extend the lifetimes of all 17 reactors initially to 40 years (from average 32 years) and then individually seeking extensions to 60 years as in the USA.

Meanwhile Germany spends some EUR 2.5 billion per year subsidising its coal mines to produce 55% of its electricity (cf nuclear 31% with no subsidy). Brown coal produces about 1.25 tonnes of carbon dioxide per MWh. Arising from the Kyoto accord, and as part of the differentiated EU "bubble", Germany is committed to a 21% reduction of greenhouse gas emissions by 2010.

A major element in the federal government's war of attrition through 1999-2000 against the nuclear utilities was a law retrospectively to tax funds amounting to DM 50 billion which have been contributed by electricity users and set aside in trust as provision for waste management, decommissioning nuclear power plants and rehabilitating lignite mines. Early in 1999 industry promptly served notice that this would be vigorously contested as "a blatant breach of German constitutional rights and legal principles", as depletion of these funds by some DM 25 billion through the tax will leave future generations liable for much of the future costs. However, despite a scathing attack on it by the Chancellor, Mr Schroeder, in cabinet, the tax measure was approved by the upper house on the last day that the new coalition enjoyed a majority

there.

France's previous Socialist-Green coalition, presiding over a largely nuclear-supplied electricity system which enabled it to be the world's largest net electricity exporter, made it clear that it had no intention of adopting similar policies, and expected that the impact of the German political decision was likely to be limited. There has been substantial Franco-German cooperation on development of an advanced reactor (the EPR) and on the safety improvement of early Soviet-designed reactors in Eastern Europe.

In May 2007 the International Energy Agency warned that Germany's decision to phase out nuclear power would limit its full potential to reduce carbon emissions "without a doubt." The agency urged the German government to reconsider the policy in the light of "adverse consequences."

The Federal Ministry of Economics & Technology (BMWi) implements national energy policy.

## Nuclear Fuel supply

From 1946 to 1990, some 220,000 tonnes of uranium (260,000 t  $U_3O_8$ ) was mined in the former GDR, in Saxony and East Thuringia, notably at Wismut, with substantial environmental damage. Much of this was used in Soviet weapons programs, and for fuel in Eastern Europe.

A small mine, Ellweiler, operated in West Germany 1960-89. All uranium is now imported, from Canada, Australia, Russia and elsewhere, a total of 3800 t/yr U.

Annual demand for enrichment is about 2.2 million SWU, most of which is provided by Urenco's Gronau plant, which now has a capacity of 1.8 million SWU/yr. Most of the balance is provided by Russia.

Fuel fabrication is undertaken by Siemens, mostly at Lingen in Germany.

Thirteen German reactors are licensed to use Mixed Oxide (MOX) fuel, using plutonium recycled from spent fuel. A MOX plant at Hanau in Hesse has never been allowed to operate, so all MOX fuel is imported.

## Reprocessing and Wastes

In 1963 the federal government issued a recommendation to use rock salt formations for radioactive waste disposal. In 1973 planning for a national repository started, and in 1976 the Atomic Energy Act was amended to make such disposal a responsibility of the federal government.

Until 1994 utilities were obliged to reprocess spent fuel to recover the usable portion and recycle it. From 1994 to 1998 reprocessing and direct disposal were equally acceptable to the federal government, but the policy of the coalition government from 1998 is for direct geological disposal of spent fuel and no reprocessing after mid 2005 (although firm contracts for reprocessing, totalling US\$ 7.3 billion, are in place with BNFL and Areva).

The utilities are responsible for interim storage of spent fuel, and have formed joint companies to build and operate off-site surface facilities at Ahaus and Gorleben. However, current policy is for interim storage at reactor sites.

The federal government through the Federal Office for Radiation Protection (BfS) is responsible for building and operating final repositories for high-level waste, but progress in this has been hindered by opposition from Länder governments. DBE is the company actually building and operating the repository projects - Konrad and Gorleben, while decommissioning Morsleben.

Following an exhaustive site selection process the state government of Lower Saxony in 1977 declared the salt dome at Gorleben to be the location for a national centre for disposal of radioactive wastes. It is now being studied as a possible site for geological disposal of high-level wastes. These will be about 5% of total wastes with 99% of the radioactivity. A pilot conditioning plant is there. The site could be available as a final repository from 2025.

Separated high-level wastes from past reprocessing are expected to be returned to Germany by 2022 and stored. A total of 166 large casks of glass canisters will be involved, 39 of these are already in storage at Gorleben. A further 300+ casks with canisters of compacted wastes from reprocessing could immediately go to a final repository, the canisters possibly in to boreholes.

The Ahaus facility is used for storing intermediate-level wastes. The Konrad site (a former iron ore mine) has been under development as a repository since 1975, and was licensed in 2002 for intermediate and low-level waste disposal but legal challenges were mounted. These were dismissed in March 2006 and again in April 2007. A construction licence was issued in January 2008. Konrad will take some 300,000 cubic metres of wastes - 95% of the country's waste volume, with 1% of the radioactivity - and may be operational about 2013. DBE plan for it eventually to accommodate 650,000 cubic metres of wastes.

The salt dome repository at Morsleben in east Germany for low and intermediate-level wastes was licensed in 1981 and closed in 1998.

## Decommissioning

Seventeen experimental and commercial reactors have been shut down and are being decommissioned. Five of these are VVER-440 units at Greifswald, closed in 1990 following reunification. Five are various BWRs, two are HTGRs, one is the large and relatively modern Muelheim-Kaerlich PWR shut down since 1988, one is Stade PWR closed in November 2003, one is Obrigheim PWR closed in May 2005, one is a prototype GCHWR and one is a prototype VVER. Eleven involve full demolition and site clearance. These will create about 10,000 cubic metres of decommissioning waste.

Decommissioning the currently operating reactors is expected to produce some 115,000 cubic metres of such wastes.

## Research

From 1956 a number of nuclear research centres were set up in West Germany, and most of these as well as university institutes were equipped with research reactors. Most of these reactors are now shut down and the centres have changed their roles.

In 1960 a 16 MWe experimental nuclear power plant ordered in 1958 was started up. Then in 1961 the **AVR** 13 MWe experimental high temperature reactor at Juelich was ordered, with fuel as a pebble bed. It operated for over 750 weeks from 1967 to 1988, most of the time with thorium-based fuel.

The 300 MWe **THTR** reactor at Uentrop was developed from the AVR and operated 1985-88 also using thorium-based fuel. Fuel fabrication was on an industrial scale. Several design features made the AVR unsuccessful, though the basic pebble bed concept was again proven. It drove a steam turbine.

An 80 MWe **HTR-modul** was then designed by Siemens and licensed in 1989, but was not constructed.

A fast breeder reactor, the 17 MWe Kompakt KNK 2 was built by Siemens and ran from 1978 to 1991. The much larger **SNR-300** was also constructed by Siemens in the 1970s but for political reasons was never commissioned. The 1500 MWe SNR-2 was designed by KWU but not built.

In East Germany a research institute opened in 1956 and its research reactor started operation the following year. The first East German power reactor, the 70 MWe **Rheinsberg** PWR, was connected to the grid in 1966, operating until 1990.

In 1969 Siemens and AEG merged their nuclear activities to form Kraftwerk Union (KWU). KWU developed a series of PWR units culminating in the standardised 1300 MWe Konvoi design, of which only three were built (though six preceding ones were similar).

Through the 1990s Siemens-KWU with utilities worked with EdF and Framatome to develop the 1600 MWe EPR, now marketed by Framatome ANP (formed from Framatome-Siemens nuclear merger).

At Juelich, Urenco maintains a centrifuge development and manufacturing centre.

## Regulation and safety

In 1955 the West German government established an Atomic Ministry (BfA) with strong European links. The Atomic Energy Act was promulgated in 1959 and is the core legislation relevant to licensing and safety. The Radiation Protection Ordinance, Nuclear Licensing Procedure Ordinance and six other ordinances support this.

The Federal Ministry of Environment (BMU) is the main national body involved with licensing and supervising nuclear facilities, and is supported by the Federal Office for Radiation Protection - Bundesamt für Strahlenschutz (BfS). However, licensing of nuclear power plants and other facilities is actually done by the states, which are responsible for implementing federal laws. The BMU supervises this and can issue binding directives.

The BfS is responsible for construction and operation of nuclear waste facilities. Individual utilities are responsible for setting aside funds for waste disposal and decommissioning, As of 2003, some EUR 35 billion had been set aside - about 55% of this for wastes and 45% for decommissioning.

## Public Opinion

German public sentiment has been split in relation to support of nuclear energy. A poll late in 1997 showed that some 81% of Germans wanted existing nuclear plants to continue operating, the highest level for many years and well up from the 1991 figure of 64%. The vast majority of Germans expected nuclear energy to be widely used in the foreseeable future. The poll also showed a sharp drop in sympathy for militant protests against transport of radioactive waste.

After the crucial October 1998 election a poll confirmed German public support for nuclear energy. Overall 77% supported the continued use of nuclear energy, while only 13% favoured the immediate closure of nuclear power plants.

In November 1998 Germany's electric utilities issued a joint statement pointing out that achievement of greenhouse goals would not be possible without nuclear energy. A few days later the Federation of German Industries declared that the "politically undisturbed operation" of existing nuclear plants was a prerequisite for its cooperation in reaching greenhouse gas emission targets. Nuclear energy then avoided the emission of about 170 million tonnes per year of carbon dioxide, compared with 260 Mt/yr being emitted by other German power plants.

A poll early in 2007 found that 61% of Germans opposed the government's plans to phase out nuclear power by 2020, while 34% favoured a phase out. Another poll in mid 2008 (N=500) showed that 46% of Germans want the country to continue using nuclear energy; another 46% said they support the nuclear phase out policy, and 8% were undecided.

## Non-proliferation

Germany is a party to the Nuclear Non-Proliferation Treaty (NPT) as a non-nuclear weapons state. Its safeguards agreement under the NPT came into force in 1977 and it is also under the Euratom safeguards arrangement. In 1998 it signed the Additional Protocol in relation to its safeguards agreements with both IAEA and Euratom. It is also a member of the Nuclear Suppliers Group.

### **Sources:**

*Nuclear Engineering International, Feb 1996; July 2004;*  
*NEI World Nuclear Industry Handbook 2004;*  
*IAEA 2003, Country Nuclear Power Profiles.*

© World Nuclear Association. All rights reserved  
'Promoting the peaceful worldwide use of nuclear power as a sustainable energy resource'  
[Contact WNA](#)